Human Capital Development and Technological Innovation in Kenyan Universities: The Mediating and Moderating Role of Intermediaries

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ABSTRACT

Universities are increasingly expected to translate Human Capital Development (HCD) into Technological Innovation (TI), yet limited empirical evidence exists on the mechanisms through which this relationship operates. In particular, the role of intermediary structures in linking human capital and innovation remains insufficiently examined. This study investigates Innovation Intermediaries Development (IID) as both a mediating and moderating construct in the association between HCD and TI in Kenyan universities. A cross-sectional quantitative design based on perceptual data is adopted. Data from 284 respondents across Kenyan universities are analysed using covariance-based structural equation modelling (SEM) in IBM SPSS Amos. The study tests a consolidated model incorporating direct, mediating, and moderating associations among HCD, IID, and TI. The findings indicate that HCD is positively and significantly associated with TI ($\beta = 0.181$, $p = 0.019$) and IID ($\beta = 0.570$, $p < 0.001$), while IID is also positively associated with TI ($\beta = 0.299$, $p < 0.001$). In addition, IID significantly mediates the association between HCD and TI ($\beta = 0.102$, $p = 0.001$) and moderates the relationship ($\beta = 0.265$, $p < 0.001$), such that the association between HCD and TI is stronger at higher levels of IID. Institutional age is also positively associated with TI ($\beta = 0.119$, $p = 0.001$). The study concludes that intermediary development is associated with the relationship between HCD and technological innovation in universities. The findings suggest that universities and policymakers may complement investments in human capital with efforts to strengthen intermediary structures, such as innovation hubs and technology transfer offices, to support innovation-related activities.

Key Words: Human Capital Development, Intermediaries, Innovation, Mediation, Moderation.

INTRODUCTION

TI has become a critical driver of competitiveness and socio-economic transformation globally, with universities and industries under increasing pressure to translate human capital investments into marketable outputs(Awode & Oduola, 2025). In advanced economies, HCD initiatives, such as structured training, internships, exchange programs, and capacity building, are widely recognized as cornerstones of innovation ecosystems, enabling organizations to build absorptive capacity, strengthen workforce skills, and accelerate commercialization (Podra et al., 2020). These initiatives foster entrepreneurial ventures, enhance knowledge transfer, and reinforce national innovation systems (Kruger & Steyn, 2020)

Existing studies predominantly emphasize a direct link between HCD and TI, with limited consideration of the institutional structures that facilitate knowledge transformation into technological outcomes.(Koria et al., 2021) Yet HCD collaborations often remain fragmented, donor-driven, and poorly integrated into industrial strategies. Small and medium enterprises, which dominate Kenya's industrial sector, face persistent barriers including limited absorptive capacity, weak mentorship structures, and shallow integration of university placements into innovation projects (Wendo et al., 2025) These constraints hinder the translation of workforce training into TI, weakening the contribution of universities to national innovation performance.

Intermediaries have emerged as pivotal actors in bridging universities and industry. Positioned as connectors, brokers, and facilitators, intermediaries reduce information asymmetries, mobilize resources, and align collaborative activities with innovation priorities (Alexandre et al., 2022).. Within the Triple Helix framework, intermediaries complement the traditional university–industry–government nexus by enhancing coordination and trust. Human Capital Theory underscores the role of education, training, and skill development in enhancing innovation capacity (Supriadi et al., 2025). , while Open Innovation theory highlights the importance of external knowledge flows and intermediaries institutions in enabling collaboration.

Human capital is widely recognized as a fundamental driver of TI in universities, yet empirical findings on how this relationship unfolds remain mixed, particularly in developing country contexts (Bambi & Pea-Assounga, 2025). Universities increasingly establish intermediaries such as technology transfer offices, innovation hubs, incubators, and industry liaison units to support collaboration, knowledge commercialization, and research utilization. However, these intermediaries are often examined as peripheral support mechanisms rather than as integral components influencing the effectiveness of human capital in driving innovation. Furthermore, prior research has largely overlooked the possibility that intermediaries may play as mechanisms through which human capital influences TI, while simultaneously shaping the strength of this relationship (Kozhushko, 2021; Kyambo et al., 2021; Lio, 2021) . This oversight has resulted in an incomplete understanding of how universities convert investments in human capital into TIs, especially in Kenyan universities where intermediaries' structures are expanding but their functional impact remains insufficiently examined. Therefore, this study seeks to address this gap by investigating the dual mediating and moderating role of intermediaries in the relationship between HCD and TI, offering a more comprehensive perspective on building innovation capacity in Kenyan universities.

LITERATURE REVIEW

Theoretical review

This study is grounded on Human Capital Theory (HCT) (Becker, 1994) and the Resource-Based View (RBV).(Penrose, 2009) Human Capital Theory posits that investments in education, training, and skill development enhance the productivity and innovative capacity of individuals (Becker, 1964). In the university context, human capital is reflected in the knowledge, competencies, and expertise of academic staff and researchers, which form the foundation for knowledge creation and TI. Accordingly, universities with higher levels of human capital are expected to generate superior innovation outcomes due to enhanced cognitive and technical capabilities.

Complementing HCT, the RBV argues that organizational performance depends on the effective utilization of strategic resources that are valuable, rare, inimitable, and non-substitutable. In universities, human capital represents a core strategic resource; however, RBV emphasizes that possessing resources alone is insufficient unless they are effectively organized and deployed to generate value. This highlights the importance of internal and external mechanisms that enable the transformation of human capital into innovation outcomes.

Despite the explanatory power of HCT and RBV, both theories provide limited insight into the institutional mechanisms through which human capital is converted into TI in complex university systems. The study introduces intermediaries as critical enabling structures within the innovation ecosystem. intermediaries are conceptualized as mechanisms that bridge human capital and innovation processes

Integrating HCT and the RBV provides a robust foundation for this dual-role conceptualization. From an HCT perspective, the human capital represented by specialized academic expertise and researcher skills is the primary driver of value; however, RBV posits that for this capital to yield a competitive advantage, it must be effectively bundled and deployed through organizational structures. As mediators, intermediaries function as the mechanical "conversion engine" that transforms the raw potential of HCT into codified, VRIN resources (RBV), thereby explaining the process through which knowledge becomes a TI. Simultaneously. as moderators, intermediaries act as a strategic catalyst; they do not just facilitate the path but amplify the resource picking and capability building efficiency of the firm (Bäumle, 2025; Feser, 2023).. This dual role suggests that while human capital is the essential ingredient for innovation, the presence of effective

intermediaries' systems determines both the pathway of its transformation and the intensity of its impact on innovation performance.

Hypothesis Development

Human Capital Development and Technological innovation

Human capital refers to the stock of knowledge, skills, competencies, and experience possessed by individuals that can be applied to create economic and social value within organizations (David, 2000). In universities, HCD is primarily embodied in academic staff, researchers, and students whose expertise and capabilities determine the institution's ability to generate, absorb, and apply knowledge. TI in the university context refers to the development and application of new or improved ideas, processes, products, or services that enhance research output, teaching quality, and knowledge transfer to industry and society. It reflects the extent to which universities transform intellectual capabilities into tangible innovations such as patents, research commercialization, digital solutions, and collaborative technologies.

From an RBV perspective, firms with superior human capital are better positioned for innovation. Their specialized skills allow them to generate and integrate knowledge more effectively. This expertise enables them to apply complex information to achieve better innovation outcomes. (David, 2000; Pasban & Nojedeh, 2016) The RBV further argues that resources such as human capital are valuable, rare, inimitable, and non-substitutable, making them critical for sustaining innovation performance in knowledge-based institutions (Gerhart & Feng, 2021). In this regard, human capital embedded within universities is a strategic asset that enhances institutional capability to innovate when effectively organized and utilized. The RBV suggests that human capital alone is insufficient for innovation; it requires effective coordination through enabling systems, such as intermediaries, to convert knowledge into tangible outputs.

Empirical studies in recent times suggests that HCD enhances TI. Strengthening university human capital contributes to the development of innovation capacity by improving research productivity and knowledge creation within higher education institutions (Kazuhiko, 2021). Human capital is central to advancements in science, technology, and innovation through skills development and professional training that enhance innovative performance (Abuzyarova et al., 2019) Investments in education and training significantly increase innovation activity, highlighting human capital as a driver of research and technological development (Teslenko et al., 2021). Higher levels of university education and continuous HCD improve innovation outcomes by strengthening competencies required for knowledge generation and application (Okebukola, 2014). Expansion of human capital, particularly through universities, promotes innovation by enhancing the availability of skilled researchers and fostering knowledge spill overs (Chen et al., 2025).. From these empirical and theoretical view, the following hypothesis is proposed.

H1: HCD positively influences TI in Kenyan universities

Innovation Intermediaries as Mediators

Intermediaries such as incubators, hubs, accelerators, and science parks play a pivotal role in bridging the gap between workforce training and commercialization. They coordinate partnerships, reduce transaction costs, and translate human capital investments into innovation outcomes (Chen et al., 2025).. From a theoretical perspective, Human Capital Theory emphasizes the productivity gains from training, while Open Innovation underscores the permeability of organizational boundaries and the importance of external actors in facilitating knowledge flows (Becker, 1994). embody these principles by serving as conduits through which universities and firms align workforce development with innovation priorities.

In practice, intermediaries mediate the relationship between HCD and TI by ensuring that training and placements are strategically aligned with industry innovation needs. For example, incubators and science parks provide platforms for experiential learning, mentorship, and entrepreneurial experimentation, enabling students to apply their skills in innovation-active environments (Wright et al., 2008)..

Empirical evidence on intermediaries in university–industry cooperation consistently shows that intermediaries play a key mediating role in enabling innovation outcomes. intermediaries are classified as key actors that facilitate knowledge exchange and collaboration between universities and external partners (Santos et al., 2023).. They function as "middle actors" that translate and align interests between universities and industry, thereby enabling effective knowledge flow (Frølund & Ziethen, 2016).. Higher education intermediaries act as brokers and mediators that convert academic research into usable knowledge, increasing research impact and innovation relevance (Knight & Lyall, 2013).. intermediaries facilitate mediation processes by linking institutions and enabling the uptake of academic knowledge into applied innovation contexts (Cooper, 2013).. They also mediate institutional pressures and enhance collaboration efficiency within universities, strengthening innovation outcomes (Enders & Naidoo, 2019).. Overall, empirical studies consistently show that intermediaries functions primarily as mediating structures that bridge universities and external stakeholders to support TI. Therefore, we hypothesize that;

H2: Innovation intermediaries mediate the relationship between HCD and TI in Kenyan Universities.

Innovation intermediaries as Moderators

Beyond their mediating role, intermediaries also influence the strength of collaborative outcomes. By fostering trust, aligning incentives, and mobilizing resources, they condition the effectiveness of HCD initiatives (Agogué et al., 2017; Vallejo et al., 2019). Collaborations embedded within strong intermediaries' structures yield higher innovation outcomes compared to those lacking intermediaries support (Howells, 2006; Wright et al., 2008). The Triple Helix framework and Open Innovation theory both suggest that institutional strength moderates' collaboration effectiveness. intermediaries act as stabilizers within the university–industry–government nexus, ensuring that HCD collaborations are sustained and strategically aligned (Etzkowitz & Leydesdorff, 2000). Open Innovation highlights that robust intermediary manage external knowledge flows and reduce uncertainty (Chesbrough, 2003; Laursen & Salter, 2006).

Recent literature recognizes that intermediaries do not only facilitate knowledge transfer but also shape the strength and effectiveness of university (Lin et al., 2020). For instance, intermediary' organizations strengthen the effectiveness of university–industry collaboration by enhancing the benefits of firms' engagement with universities compared to direct interaction alone, indicating a contextual enhancing role in collaboration outcomes (Alexandre, Costa, Faria, & Portela, 2022,). This suggests that intermediaries condition the impact of university linkages on firm-level innovation outcomes. Similarly, evidence from entrepreneurial university ecosystems indicates that knowledge intermediaries influence the trajectory of spinoff success by strengthening the effectiveness of knowledge exchange processes, thereby shaping how university resources translate into entrepreneurial outcomes (Hayter, 2016). This highlights the contingent role of intermediaries in determining the success of innovation pathways rather than acting only as direct facilitators. In addition, studies on corporate innovation show that the impact of organizational ties on innovation performance becomes stronger when intermediaries diaries are effectively engaged, suggesting that intermediaries enhance the relationship between external collaboration and innovation outcomes (Lin et al., 2020). This is a demonstration of moderating role where intermediaries condition the strength of collaboration–innovation linkages. Therefore, the study proposes the following hypothesis.

H3: Innovation intermediaries moderate the relationship between HCD and TI in Kenyan universities.

Control Variables

To ensure the statistical validity of the hypothesized moderated mediation model, the study incorporates control variables to account for potential confounding effects. Within the framework of the Resource-Based View (RBV), a firm's (or university's) ability to innovate is influenced not only by specific HCD or intermediaries' functions but also by baseline institutional characteristics and "resource slack." Scholars recommend including these variables in the structural equation model to isolates the unique contribution of the primary predictors on TI because it ensures that the observed relationships are not merely artifacts of institutional scale or resource endowment (Atinc et al., 2012; Curado et al., 2024)

From an RBV lens, age represents a path-dependent resource that encapsulates several critical institutional advantages. Most of the time, the age of an institution typically correlates with the maturity of its organizational routines, the depth of its physical infrastructure, and its accumulated relational capital. Older universities often possess more established alumni networks and long-standing industry linkages, which facilitate the commercialization of research. Furthermore, institutional age serves as a surrogate for reputational capital; more established institutions often have a greater "brand pull" that attracts high-value R&D grants and industrial partners. The study accounted for these inherent institutional advantages, allowing for a more a true assessment of how HCD and intermediaries structures specifically drive TI.

Age has been shown to exert a positive influence across organizational outcomes. Prior empirical evidence indicates that age improves financial reporting quality by reducing discretionary accrual manipulation, reflecting stronger governance and organizational maturity (Büyükkurt, 2024). Similarly, firm age has been associated with enhanced financial performance due to accumulated operational experience and learning effects (Azzahra & Sampurno, 2023). In addition, older organizations tend to exhibit higher capital expenditure, suggesting greater investment capacity and resource availability developed over time (Khajavi & Dehghani, 2016). In the context of this study. age is therefore included as a control variable to account for organizational maturity and accumulated experience that may independently influence innovation outcomes. Older institutions are likely to possess more established knowledge bases, stronger collaborative networks, and refined administrative systems, which can facilitate both human capital development initiatives and the effective use of intermediaries. Age also accounts for other potential control variables such as firm size which are correlated (Ahnert et al., 2021; Plans, 2005). So, this study hypothesizes that

H4: Age of an institution, is significantly associated with technological innovation.

Conceptual Framework

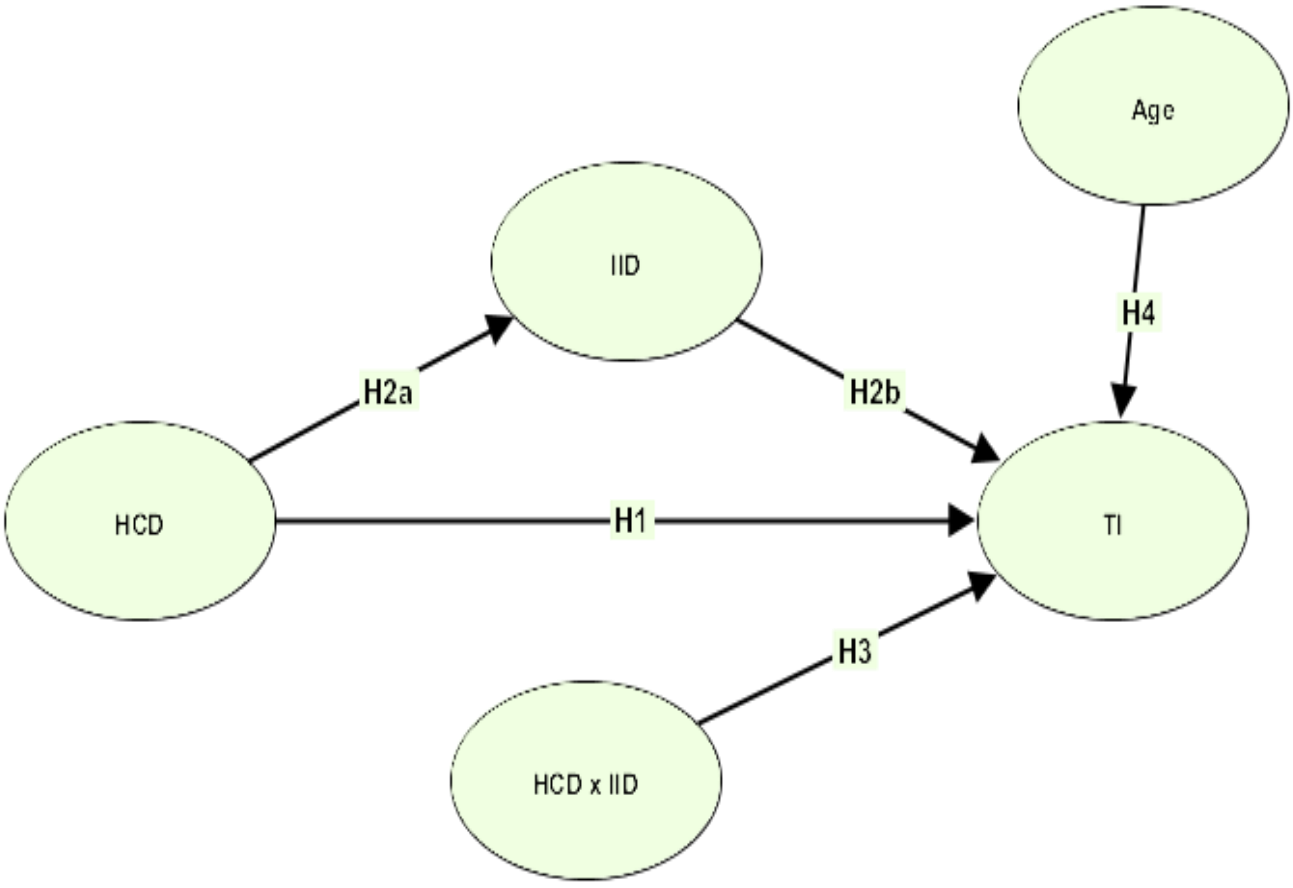


Figure 1: Conceptual model; H2a–H2b represent the mediation effect of intermediaries on HCD- TI relation. IID: Innovation Intermediary Development, HCD: Human Capital development, HCD X IID interaction term, TI: technological Innovations

The conceptual framework illustrates the hypothesized relationships among HCD, intermediaries, and TI in universities. Human capital is proposed to have a direct effect on TI (H1). In addition, intermediaries are conceptualized as a mediating variable, where human capital influences intermediaries (H2a), and intermediaries subsequently influence TI (H2b). Together, these paths represent the indirect mediating effect of intermediaries. Furthermore, intermediaries are hypothesized to moderate the relationship between HCD and TI (H3), such that the effect of HCD on TI becomes stronger in the presence of well-developed intermediary structures.

METHODOLOGY

Research Design, Participants, and Procedures

This study employs a descriptive and explanatory cross-sectional design rooted in a positivist philosophy. This foundational stance prioritizes the identification of statistical regularities and objective truths to rigorously test the hypothesized moderated mediation pathways between HCD and TI. By utilizing quantitative data to validate these complex relationships, the design ensures a structured analysis of how intermediaries function both as mechanisms and as catalysts within the innovation process (Saunders & Tosey, 2012)..

Population and sampling

The target population for this study comprises all 66 chartered universities in Kenya, encompassing both public and private institutions. Within these universities, the study specifically focuses on academic, research, and administrative staff who are directly involved in innovation, R&D, and industry-university collaborations. This specific population was selected because these individuals serve as the primary agents of knowledge creation and transfer within the higher education sector. Their specialized expertise and first-hand experience provide the necessary insights to evaluate the intersection of HCD, the effectiveness of university intermediaries, and the resulting technological innovation outputs across the Kenyan university landscape.

To select participants from the 66 chartered universities, the study employed a stratified purposive multi-stage sampling technique. This approach addressed the heterogeneity of the Kenyan university landscape, particularly regarding the varying maturity of intermediary structures like innovation hubs and technology transfer offices. In the first stage, universities were stratified by ownership (public vs. private) and level of intermediaries development (high, moderate, or emerging) to ensure contextual diversity. These results to 39 public and 27 private universities as targets. The second stage involved the purposive selection of institutions from each stratum to capture variation in intermediaries' effectiveness. Finally, purposive and stratified random sampling were used to recruit academic, research, and administrative staff specifically involved in innovation and industry collaboration.

The study targeted at least three respondents from each university thus yielding target sample of 284. This sample size was checked for adequacy through the SEM requirement lens. For this study, twelve parameters were estimated, thus, the minimum required sample size ranges between 60 and 120 observations using the 5:1 and 10:1 parameter-to-sample ratios (Sarstedt et al., 2022). However, consistent with recommended covariance-based SEM standards, a minimum of 200 observations is considered adequate (Gaskin et al., 2025). Therefore, the achieved sample size of 284 respondents exceeds the recommended thresholds, ensuring robust and stable parameter estimation in AMOS.

Data Collection and Measurement

Data were collected using a structured questionnaire. The instrument allows uniform collection of information from respondents across the universities. For this study, the questionnaire items were measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire captured information on human capital, intermediaries, and TI. Human capital items focused on staff skills, expertise, and research capacity.

Innovation Intermediaries were operationalized as innovation intermediary development (IID), reflecting the extent to which universities have established and strengthened institutional mechanisms that facilitate

collaboration, knowledge transfer, and innovation support. IID items assessed the presence and effectiveness of innovation support structures such as innovation hubs and liaison offices. TI items captured development of new technologies, research outputs, and commercialization activities.

Human capital development was measured using items capturing skills, knowledge, experience, and research capacity of academic staff. These indicators reflected the ability of university personnel to generate and apply knowledge for innovation purposes. intermediaries were measured using items that captured the presence and effectiveness of university innovation support structures, including innovation hubs, technology transfer offices, incubation centers, and industry liaison functions. The measures reflected how well these structures facilitated knowledge transfer and collaboration.

TI was measured using items that captured the extent of new product or process development, research outputs, patents, and commercialization of research findings within universities. These indicators reflected the innovation performance of the institutions

Data analysis

Data were analyzed using IBM SPSS and IBM SPSS Amos. The analysis proceeded in three stages. First, the measurement model was evaluated using Confirmatory Factor Analysis (CFA) to assess construct validity and reliability. This involved examining factor loadings, composite reliability (CR), average variance extracted (AVE), and discriminant validity. Model fit was assessed using commonly reported indices, including Chi-square, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI and the normed chi-square (CMIN/DF).

Second, the structural model was estimated within a covariance-based SEM framework to test the hypothesized relationships among HCD), IID, and TI. Mediation effects were assessed using bootstrapped indirect estimates, while moderation was examined through the interaction term (HCD × IID). The structural model was subsequently evaluated using model fit indices to ensure that the overall framework remained consistent with the observed data.

The analysis was conducted at the individual respondent level (n = 284) rather than the institutional level (66 universities), as no secondary data were available at the institutional level. Aggregating responses could have reduced variability and compromised measurement precision; thus, individual-level analysis provided a more appropriate basis for capturing variations in perceptions while still reflecting institutional conditions (Mohaghegh & Mosleh, 2009)..

A first-order reflective measurement model was adopted, as the study constructs are conceptualized as latent variables that give rise to their observed indicators (Hanafiah, 2020). In this specification, indicators are expected to be correlated and interchangeable manifestations of the underlying constructs, consistent with the theoretical nature of HCD, IID, and TI. Model parameters were estimated using Maximum Likelihood Estimation (MLE), which is appropriate for continuous data and provides efficient and consistent estimates under conditions of approximate normality (Pan & Fang, 2002)..

RESULTS

Preliminary tests results

Prior to structural equation modelling in IBM SPSS Amos, data screening and diagnostic tests were conducted to assess common method bias, normality, and multicollinearity. Common method bias was evaluated using Harman's single factor test and the Common Latent Factor (CLF) approach. The results of Harman's test showed that the first factor accounted for 43% of the total variance, which is below the recommended threshold of 50%, indicating that common method bias is not a serious concern (MacKenzie & Podsakoff, 2012).

The Common Latent Factor (CLF) approach revealed that the differences in standardized loadings between models with and without the CLF were minimal for HCD and IID ($\Delta\lambda < 0.20$). However, some TI indicators

exhibited a relatively large change in loadings ($\Delta\lambda = 0.60$), suggesting the presence of construct-specific method variance. This indicates that while common method bias is not a universal issue in the overall model, TI indicators may be more sensitive to common method effects due to their perceptual nature.

Multivariate normality was assessed using Mardia's coefficient, which produced a critical ratio of 6.8, indicating a mild deviation but remaining within the acceptable range of ≤ 10, and the Maximum Likelihood estimator was therefore considered appropriate. Multicollinearity was assessed using Variance Inflation Factor (VIF), with all values below the recommended threshold of 5, while inter-construct correlations ranged from 0.34 to 0.54, confirming the absence of multicollinearity (Figure2). Overall, the results indicate that the data meet the key assumptions for covariance-based SEM and are suitable for further CFA and structural analysis.

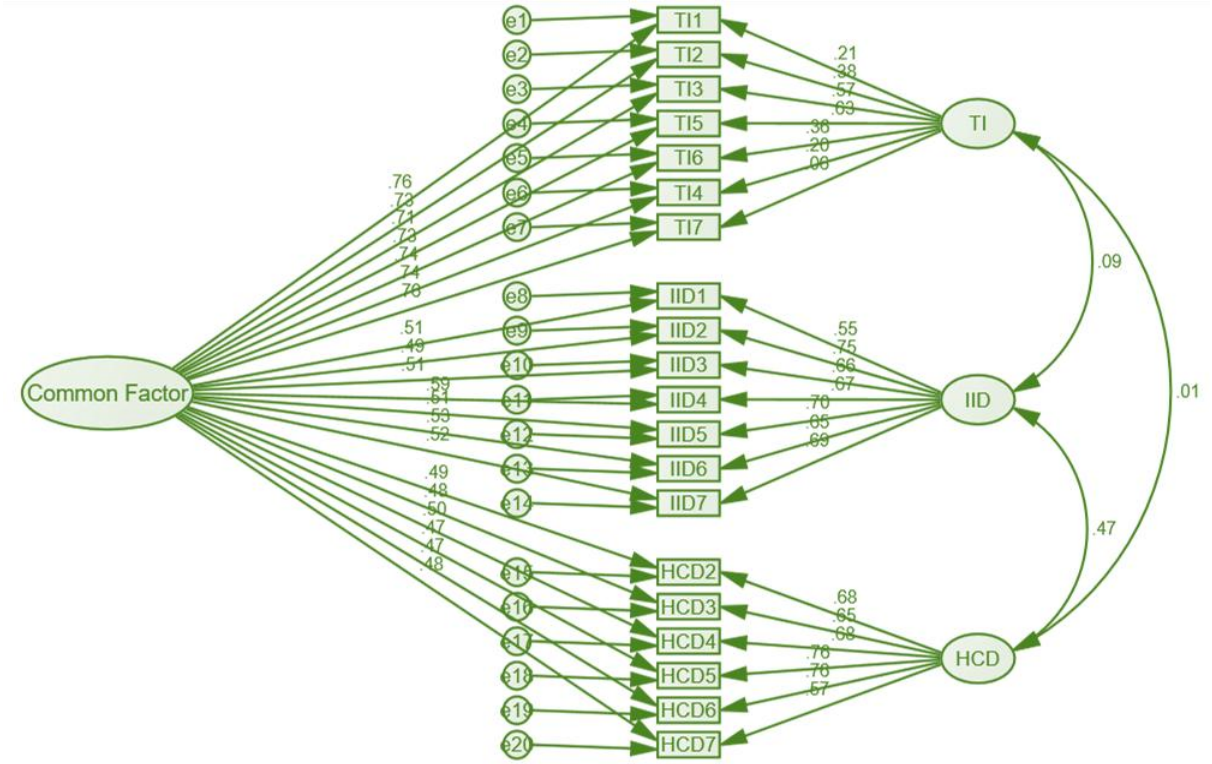


Figure 1: Common latent factor measurement model for assessing CMB

Descriptive Results

Table 1 reports the sampled characteristics of the universities. The sample included both public and private universities, with public institutions forming a slight majority (55.2%). Respondents were drawn evenly from academic staff (50.0%), TTOs (25.0%), and research/innovation units (25.0%), ensuring balanced representation of key actors in university innovation systems. The participating institutions also reflected diverse stages of institutional maturity, ranging from emerging universities to well-established ones, indicating broad coverage of institutional experience and capacity.

Table 1: Descriptive Profile of Sampled Universities and Respondents

Variable	Category	Frequency	Percentage (%)
University Type	Public	32	55.2
	Private	26	44.8
Functional Unit	Academic Staff	116	50.0
	TTO Staff	58	25.0
	Research/Innovation Office	58	25.0
Age of University	Below 15 years	12	20.7
	15–30 years	27	46.6
	Above 30 years	19	32.8

Exploratory Factor Analysis

Table 2 shows the EFA structure results to examine the underlying factor structure of the measurement items prior to confirmatory factor analysis (CFA). Principal Component Analysis with Varimax rotation extracted three factors with eigenvalues greater than 1, explaining a cumulative variance of 70.797%. The factor structure aligned with the theoretical constructs of HCD, IID and TI, supporting construct validity. The KMO value exceeded the recommended threshold of 0.60, and Bartlett's Test was significant ($p < 0.001$), indicating that the data were appropriate for factor analysis.

Table 2: Summary of Exploratory Factor Analysis (EFA) Results

Component	Eigenvalue	% of Variance	Cumulative %
1	9.053	43.108	43.108
2	3.490	16.618	59.726
3	2.325	11.071	70.797
Note: Kaiser–Meyer–Olkin (KMO) value: 0.904, | Bartlett's Test of Sphericity | χ^2 (210) = 2740.711, $p < 0.001$			

Measurement model

Figure 2 presents the measurement model used to evaluate model adequacy through the assessment of factor loadings, model fit indices, reliability, and validity. From the results, most items exhibit factor loadings above the recommended threshold of 0.70, while a few falls slightly below this level but remain above the acceptable minimum of 0.60. In addition, the inter-construct correlations range from 0.34 to 0.54, indicating moderate relationships among the constructs and supporting their empirical distinctiveness.

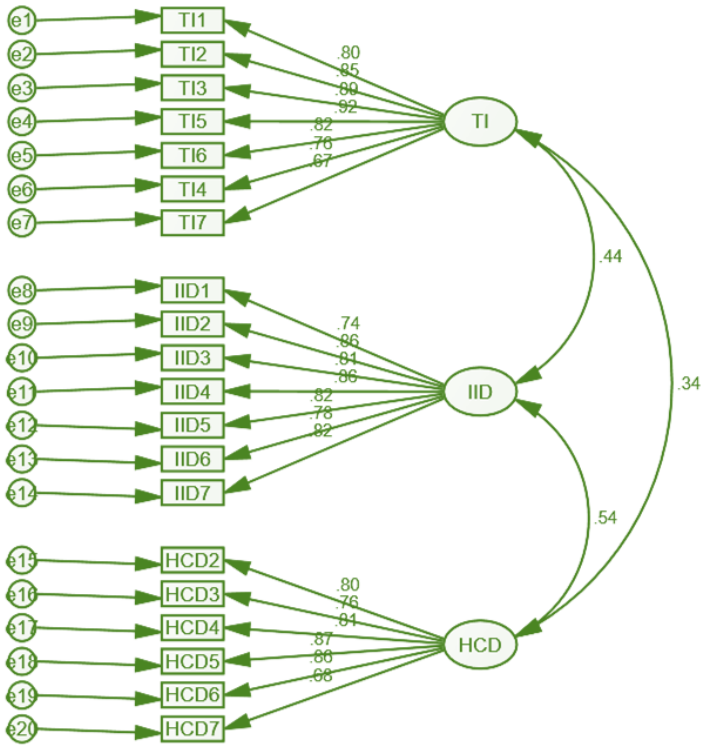


Figure 2: CFA Measurement Model with Standardized Estimates and Inter-Construct Correlations

On validity and reliability results reported in Table 3, the measurement model demonstrated strong reliability and validity. Composite reliability (CR) values are all above the recommended threshold of 0.70, indicating good internal consistency (Hair et al., 2019). Convergent validity is established, as the AVE values exceeds the recommended threshold of 0.50 (Fornell & Larcker, 1981). Discriminant validity is also demonstrated because the square roots of AVE (0.893 for IID, 0.854 for TI, and 0.731 for HCD are greater than the corresponding inter-construct correlations. In addition, the Maximum Shared Variance (MSV) values are lower than the AVE for all constructs, further supporting construct distinctiveness.

Table 3 Reliability and Validity Test Results

	CR	AVE	MSV	MaxR(H)	IID	TI	HCD
IID	0.922	0.798	0.277	0.952	0.893		
TI	0.890	0.730	0.222	0.891	0.450< .001	0.854	
HCD	0.769	0.535	0.277	0.812	0.526< .001	0.363< .001	0.731

Finally, regarding fit results reported in Table 4 shows that the measurement model demonstrates a good fit to the data. The normed chi-square (CMIN/DF) indicates an excellent fit, showing that the model is neither over- nor under-fitted. The Comparative Fit Index (CFI) also suggests that the proposed model fits the data substantially better than the null model. The Standardized Root Mean Square Residual (SRMR) shows a low level of residuals, indicating minimal differences between the observed and predicted correlations. Similarly, the Root Mean Square Error of Approximation (RMSEA) confirms a close approximation of the model to the population covariance matrix. The PClose value further supports the presence of a close-fitting model.

Table 4: Model fit results and interpretation

Measure	**Estimate**	**Threshold**	**Interpretation**
CMIN	48.136	--	--
DF	29	--	--
CMIN/DF	1.660	Between 1 and 3	Excellent
CFI	0.991	>0.95	Excellent
SRMR	0.035	<0.08	Excellent
RMSEA	0.042	<0.06	Excellent
PClose	0.729	>0.05	Excellent

Structural model

Figure 3 presents the structural model with standardized coefficients, while Table 4 reports the corresponding unstandardized estimates. The results indicate that Human Capital Development (HCD) has a positive and significant direct effect on Technological Innovation (TI) (p = .019), supporting H1. Regarding mediation, HCD is positively associated with IID (p < .05), and IID, in turn, has a strong positive effect on TI (p < .001). The indirect effect of HCD on TI through IID is also significant (p = .001), supporting H2 and indicating partial mediation. Furthermore, the interaction term HCD*IID is positive and significant (p < .001), supporting H3. This suggests that IID strengthens the relationship between HCD and TI, such that the positive effect of HCD on TI is more pronounced at higher levels of perceived IID.

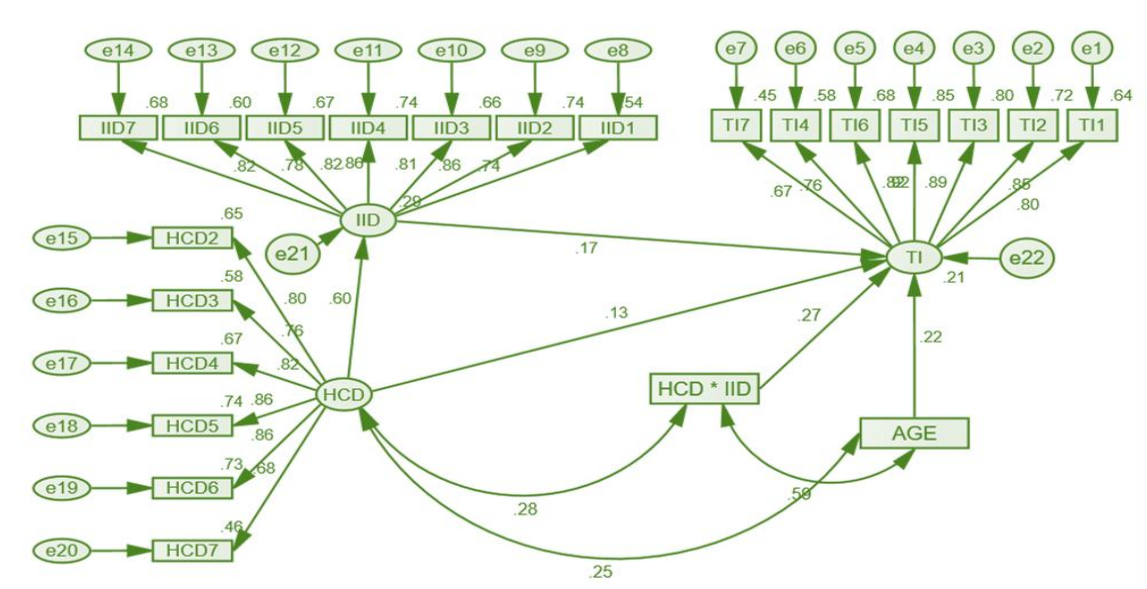
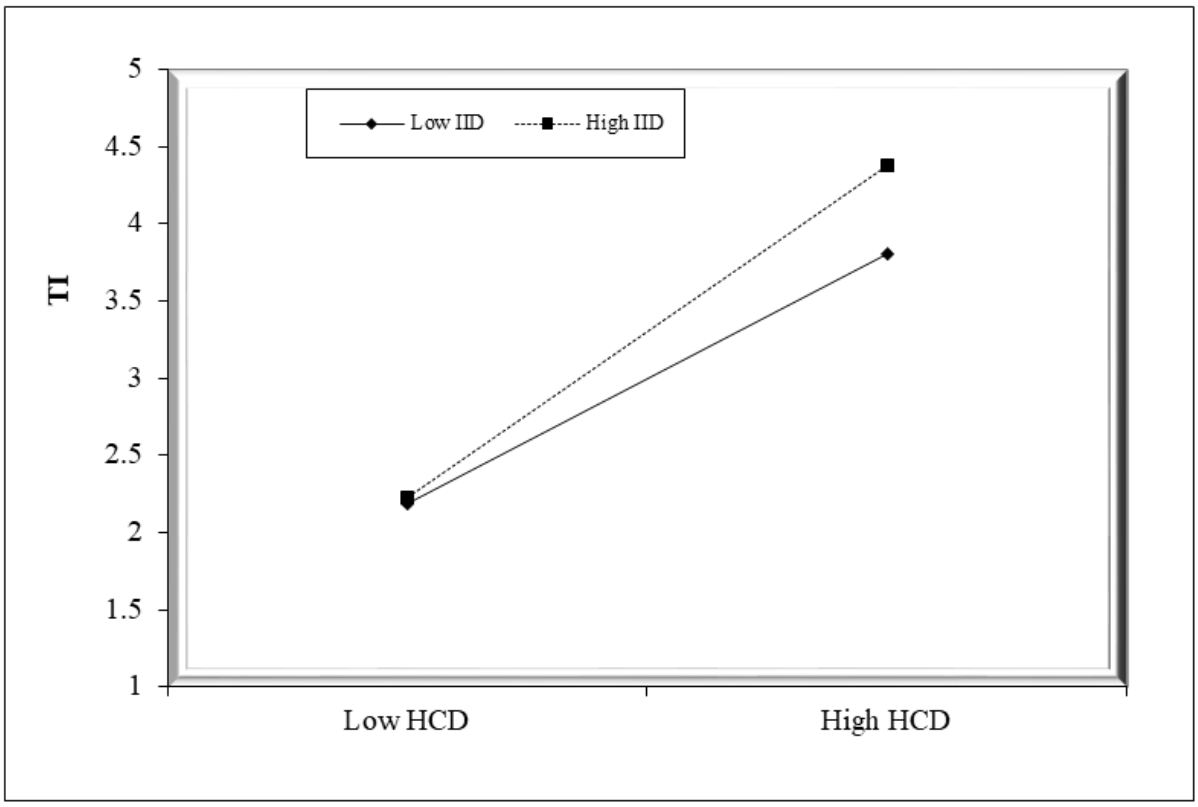


Figure 3: Structural Model with Standardized Coefficients

Table 5: Regression Weights:

	Path			Unstandardized estimates	S.E.	C.R.	P
Direct effect							
H1	TI	<---	HCD	.181	.077	2.336	.019
H3	TI	<---	HCD*IID	.265	.041	6.501	***
	TI	<---	Age	.119	.036	3.280	.001
Indirect effect							
H2	TI	<---	IID	.299	.066	4.539	***
	IID	<--	HCD	.570	.061	9.350	***
	TI	<---	IID<---HCD	.102	.048	3.479	001

Subsequently, a significant effect of age on TI was established, indicating that institutional maturity is meaningfully associated with variations in perceived innovation outcomes, H4 is supported. The explanatory capacity of the model is commonly assessed using the coefficient of determination (R^2) or its equivalent, the Cohen's effect size. The moderated mediation model account for 34% ($R^2 = .34$) of the variance in TI when IID is included as both a mediator and moderator. Figure 4 shows the moderation plot reaffirming that at high IID, the effect of HCD on TI is stronger than at low IID



Key takeaway of results: Intermediaries play a dual role in this study. As a mediator, intermediaries act as a transmission mechanism through which human capital development influences technological innovation. Conversely, as a moderator, intermediaries condition the strength of this relationship, enhancing or weakening the impact of human capital depending on their level of effectiveness.

DISCUSSION

The key findings indicate that HCD is positively and significantly associated with IID, which in turn is positively associated with TI in universities. The results also show a significant direct association between HCD and TI, suggesting that higher perceived levels of skills, training, experience, and research capacity are related to higher perceived innovation outcomes. In addition, IID was found to significantly mediate the association between human capital development and TI. More importantly, the interaction between human capital development and IID level was also significant, indicating that the positive association between human

capital development and TI is stronger at higher levels of perceived intermediary development. Furthermore, institutional age was significantly associated with technological innovation, suggesting that perceived institutional maturity is related to variation in innovation outcomes.

The findings of this study both support and extend existing literature on human capital, intermediaries, and technological innovation in universities. Consistent with Human Capital Theory and prior empirical studies, the results indicate that human capital development is positively associated with technological innovation, reinforcing the view that skills, training, and research capacity are linked to technological development in higher education institutions. Similarly, the positive association between intermediary development and technological innovation aligns with existing literature that positions intermediary structures as facilitators of knowledge transfer and university–industry collaboration. Prior studies have largely emphasized intermediaries as mediating mechanisms connecting universities with external actors and supporting innovation-related activities, and the present findings provide evidence consistent with this role in the Kenyan university context.

Moreover, this study extends existing literature by examining IID as both a mediator and a moderator in the association between human capital development and technological innovation. This dual role has rarely been examined empirically in prior studies, which often treat mediation and moderation independently. The results indicate that the positive association between human capital development and technological innovation varies across levels of perceived intermediary development, suggesting that stronger intermediary systems are linked to a stronger relationship between human capital development and innovation. This contributes to theoretical understanding by highlighting the complementary role of intermediary development within the human capital–innovation nexus in universities.

The findings offer practical implications for university management. The results suggest that HCD alone may not be sufficient to support higher levels of perceived technological innovation. Strengthening intermediary structures such as innovation hubs, technology transfer offices, and industry liaison units is also associated with higher perceived innovation outcomes. These structures are linked to the translation of academic skills and knowledge into innovation-related activities, including patents, start-ups, and research commercialization. Enhancing such mechanisms may support more effective knowledge utilization within universities.

From a policy perspective, the results highlight the importance of supporting the institutionalization of intermediary systems within universities. Policy initiatives may consider complementing investments in HCD with support for innovation facilitation structures that connect universities with industry and other stakeholders. This may be particularly relevant in developing contexts where intermediary systems are still emerging and unevenly distributed across institutions. Methodologically, the study contributes by applying a consolidated SEM framework that simultaneously examines direct, mediating, and moderating associations within a single model. This integrated approach provides a more comprehensive understanding of the interrelationships among constructs compared to models that examine mediation or moderation separately.

The additional positive association between institutional age and TI is consistent with prior studies emphasizing the role of accumulated experience in innovation-related activities. For example, experienced academic actors within university ecosystems have been linked to greater engagement in innovation and knowledge commercialization through intermediary structures (Hayter, 2016). This suggests that accumulated experience may be associated with improved ability to navigate collaboration networks, access resources, and engage in innovation activities. The present findings therefore align with the view that experienced personnel, alongside HCD initiatives and intermediary mechanisms, are associated with higher perceived technological innovation within universities.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish causal relationships among HCD, IID, and technological innovation, as SEM does not confirm temporal ordering; future research may adopt longitudinal or experimental designs to better capture causal dynamics. Second, the use of self-reported perceptual data may

introduce response bias, although diagnostic tests, including Harman's single-factor test and the Common Latent Factor (CLF) approach, indicate that common method bias is not a significant concern. Third, the study is context-specific to Kenyan universities, which may limit the generalizability of the findings to other institutional and national settings. Fourth, while institutional age was controlled for, other relevant factors such as university size, research funding, leadership, and disciplinary orientation were not included and may influence innovation outcomes. Finally, IID was treated as a composite construct, which may obscure differences across specific intermediary mechanisms; future studies could disaggregate these to provide more nuanced insights.

CONCLUSION AND RECOMMENDATIONS

The findings indicate that higher perceived levels of HCD are associated with higher perceived technological innovation, particularly where intermediary structures are also well developed. This suggests that universities may benefit from complementing investments in training, skills development, and research capacity with efforts to strengthen intermediary mechanisms such as innovation hubs, technology transfer offices, and industry linkage units. These structures are linked to improved coordination of knowledge transfer and engagement with external stakeholders. Policymakers may also consider supporting the institutionalization and sustained funding of intermediary systems within universities. Strengthening both HCD initiatives and intermediary structures may enhance the capacity of universities to support technological innovation.

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Ethical Statement

Participation in this study was voluntary, and respondents were informed of the purpose of the research before data collection. Confidentiality and anonymity of the participants were assured, and the information provided was used strictly for academic purposes. No personal identifiers were collected, and respondents had the right to withdraw from the study at any stage.

Conflict Of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Availability Statement:

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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